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Resource Management on Smart Micro Grid by Embedded Networking

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Abstract

Smart Grid, the next generation electric grid offers continuous monitoring and control which needs management of resources like measured data, control information, relays, switches etc. These resources will increase as the grid emerges and management of these scattered, bulk and highly complicated data will become difficult with conventional data storing and resource management mechanisms, which makes the cloud model of resource management relevant and significant. This paper deals with the formation of an embedded networking with six systems. Graphical User Interfaces (GUI) are created for different stake holders like consumers, energy traders, operators etc. through which they can access and control the grid assets. The proposed system will improve the performance of the grid by enabling various functionalities such as: analyzing energy usage, managing peak usage, demand management, trading of electricity between smart grid stakeholders such as consumers, operators, generators etc., which ensure efficient operation and management of the smart micro grid.

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1. Introduction

In conventional power system, central power stations generate electricity and it is distributed to consumers via power system networks. To improve flexibility, power quality, reliability, security and efficiency, the grid is to be made smarter by integrating information technology, automation, telecommunications and electric network control, etc. [1], [2]. As per the European Technology Platform Smart Grid (ETPSG) smart grid is defined as "an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies"[3].

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The grid becomes smarter by the use of modern technologies which permits bidirectional information exchange between the utility and its customers, and the control and automation provided [4]. For achieving this, the smart grid will consists of control units, sensors, actuators, computers etc. As the grid is becoming smarter, the amount of resources like smart meter data, measured data, control information, relays, switches etc. will grow at all levels of grid, and hence there is a need of powerful and cost effective information management system for management of these heterogeneous, bulk and complex data[3]. Here, the cloud model of data management becomes very relevant and significant. The National Institute of Standards and Technology (NIST), explains cloud computing as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction"[3]. The big data centers with huge computational and storage capabilities forms the foundation for the concept of cloud computing. These data centers are managed by the cloud providers and delivers "computing as a service". Many resources are shared through the network and users can access them through connected devices. Merging cloud computing with the smart grid will enhance the performance and information management of the grid [5].

By combining smart grid and cloud computing various functionalities such as: balancing load with the demand/supply chain, the storage/transfer of generated power, keeping track of energy production from various energy sources and taking decision of switching between the high/low priority demands, analyzing consumer behavior (power usage) patterns to predict the demand in advance etc. can be achieved and thereby the performance of grid can be improved [1].

This paper deals with the design and implementation of cloud network for a laboratory scale 5 bus micro grid [6]. Measurements are taken from the buses and communicated to servers located remotely. Access to this data is provided with the help of GUIs created for different stake holders like consumers, energy traders, operators etc. according to the privileges. Distributed databases are created for smart metering, Wide Area Measurement System (WAMS) and Wide Area Control System (WACS) for wide area situational awareness of the micro grid.

2. Scope of Cloud Computing in Smart Micro Grid

Fig.1. The NIST Conceptual Model for Smart Grid [5]

Smart grid (SG), shown in Fig. 1, the next-generation power grid, will combine improved power, IT and communication technologies to obtain a prompt and intelligent control system that manages highly distributed energy delivery over the network [5]. According to National Institute of Science and Technology (NIST), the various stakeholders of SG are the ones shown in figure1 [5]. Each domain in Figure1 [5] encompasses one or more SG participants, containing gadgets, systems, or software applications that take decisions and performs applications by exchanging necessary information. The summary of each fields and actors are given in [5]. Each of these stake holders are having different responsibilities and privileges.

Customers are the end users of electrical energy. Customers must have easy and flexible options to manage their power consumption, generation, and storage. In SG both IT and communication systems work hand in hand to support many user applications, such as real-time monitoring, and control of wide spread generation, providing real time information etc. for a better customer experience [7]. Energy traders take care of the selling and buying of grid assets. The different service provided by energy traders include: analysis and optimization of pricing, balancing of demand-supply gap, energy trading between the SG actors [7].

The effective operation of the power system is ensured by the operators and they are responsible for the planning and management of electricity flow. The typical applications performed by the operators may include: network operation monitoring, network control, fault management, operation feedback analysis, operational statistics and reporting, real-time network calculation, etc. [3], [5]. Smart grid needs a progressive and useful analytics over huge heaps of data for efficient and secure operation of the grid. The prior assessment at one utility reveals that per day "22 gigabytes of data" will be generated by SG from its 2 million customers [7], [8]. To solve this "Big Data Challenge" cloud model for data management is introduced. The user can store and analyze data in data centers with the help of cloud computing service providers as "pay-as-you-go" services. The user can request these services when needed [9].

The effective use of cloud computing and its benefits in smart grid to manage the SG applications is studied in detail by researchers. Balijepalli *et al.* [10] introduced a new smart grid standard called "Green Button" and presented a tool for demand-side management based on that standard. Simhan *et al.* [8] analyzed different cloud technologies, and suitable cloud software platforms for addressing "dynamic demand response (D^2R)" challenges in SG. Rusitschka *et al.* [7] recommended a model for managing SG real time data considering specific characteristics of cloud computing. Samaresh Bera *et al.* [13] addressed many cloud applications in smart grid for better energy distribution. It also described the usage of cloud computing applications for the evaluation of energy management methods in smart grid. Simhan Yogesh *et al.* [14] analyze the prospects and difficulties in implementing cloud technology in consumer side of energy management. Melike Yigit *et al.* [15] studied SG and cloud architecture with technical and security view points which are demonstrated with some applications and projects.

The main three services provided by cloud providers are: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). This three-layer service model is known as the SPI model [11]. Different open source cloud computing softwares are available for building private and public cloud network, such as Cloud Stack (IaaS), Open Stack (IaaS), Eucalyptus (IaaS), Amazon EC2 (IaaS) and Microsoft Windows Azure (IaaS & PaaS).

3. System Description

The communication possibilities of smart grid are described in this section. The measured values from Real Time Data Collection Units (RTDCUs) are given to the cloud network either directly or via data concentrator according to the distance between them. The configuration messages are send back to the RTDCU. Similarly Smart meter data is send to the cloud via communication network and the configuration message is send back to the smart meter. Based on the data obtained from smart meter and RTDCU control decision is taken and control message is send to the corresponding control/actuator units and the status of the control/actuator units are transmitted back to the cloud network. Thus bidirectional communication is achieved between the nodes. The measured data from the nodes are stored in corresponding database. Since the nodes are distributed over a wide geographic area, the databases are also distributed. The distributed database can be accessed remotely from anywhere through the cloud network. In the proposed cloud system, measurements are taken and given to the cloud via communication network, and different stake holders can view these data through GUIs created, by accessing corresponding database via cloud services. In the cloud control decisions are made based on the received measurement values and it is communicated to the respective control units.

The topology for the system is selected based on laboratory scale 5 bus micro grid [6] as shown in Fig. 2. Among six servers, two are dedicated for WAMS, next two servers are dedicated for WACS and the rest two are for the smart meters. In WAMS, measured data is collected from RTDCUs and given to server via DCs. The data received from DCs will be analyzed in the servers and necessary control action will be taken with help of WACS. The location of servers in both WACS and WAMS are based on the distance between DCs, utility owning the infrastructure, type of utility, cyber security issues, operational issues etc.

Smart meters are installed in consumer homes, to record and transmit energy consumed by the consumers. These meter readings are sent to the server directly or via data collecting nodes by multi hopping. Data collecting node will collect meter reading from homes and send to the server. As the grid expands, more number of servers must be added to the network. All the servers are interconnected to form the topology of the system as shown in Fig. 3, so that data can be accessed from any of the networked servers from any location.

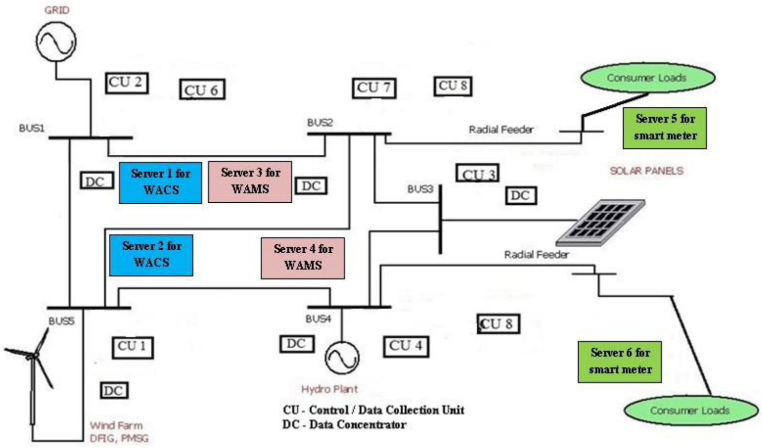

Fig. 2. Laboratory scale five bus micro grid including servers

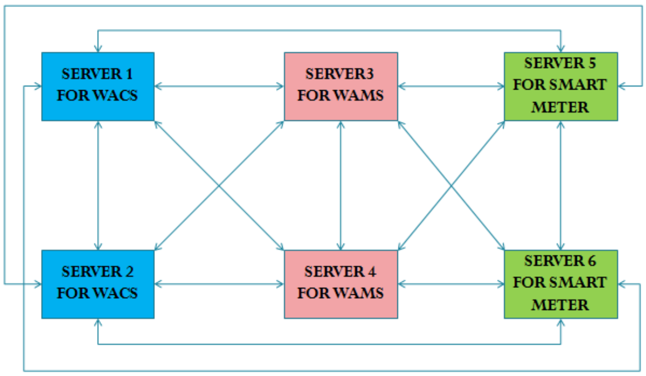

Fig. 3. Topology of the cloud system

4. Implementation

Six systems are interconnected via LAN (Local Area Network) for the resource sharing as shown in Fig. 4. Database for WAMS, WACS and smart metering are distributed among these systems. GUIs for the SG stakeholders are shared in the systems for remote monitoring and control.

Bidirectional communication between node and server is as shown in the Fig. 5. Arduino board is acting as the control units and with the help of Arduino board and processing IDE, data is entered in database located in the system. The systems are interconnected to form a cloud network and the database and GUIs are shared in the network. According to the control message from server the controller will control the end devices.

5. Results

An embedded networking system for resource sharing is implemented and GUIs for different stake holders (User, Operator and energy trader) are shared among the network. MySql database was used and NetBeans IDE 7.1

is used for creating GUIs (language: Php). Wamp server 2.4 is used for local hosting. Bidirectional communication is achieved between server and database.

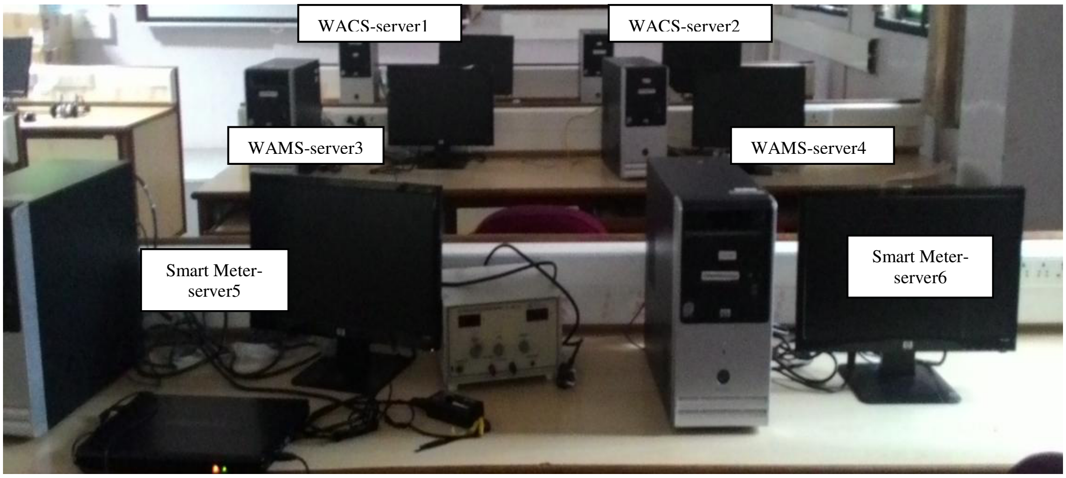

Fig. 4. Topology implementation of proposed work

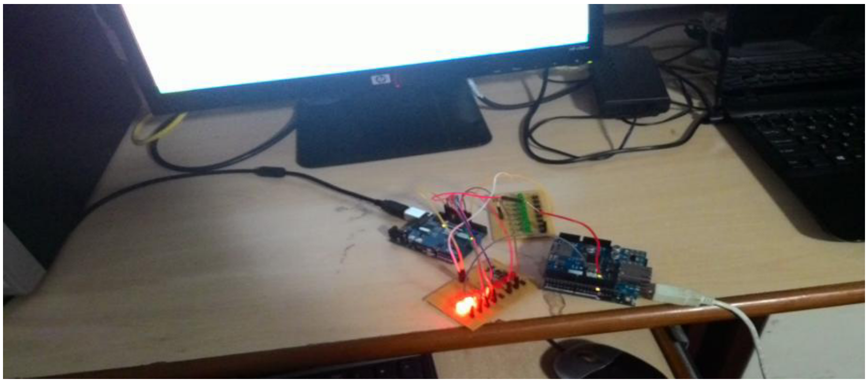

Fig. 5. Bidirectional communication between nodes and server

Data can be retrieved and viewed with the help of GUI from the distributed databases. Through the GUI a consumer can view their current energy usage, bill status, current status of individual equipments, etc. On selection of particular equipment, the power consumed by that equipment if it is on for one hour will be displayed. User is having privilege to edit own details and add equipment.GUI for a consumer is as shown in Fig. 6. An operator can monitor the status of the grid with the GUI. Operator can view the power generated and demand, the status of control devices such as circuit breakers and switches. According to the demand-supply gap operator can take decisions and send the control message to corresponding control/actuator units.

6. Conclusion

This paper presented the design and implementation of a cloud based embedded networking system for distributed resource management in smart micro grid. With the help of distributed networking system based on laboratory scale 5 bus micro grid, SG stake holders can manage the resources connected to it. Users can operate the appliances remotely from anywhere at any time. Status of the grid is analyzed by the SG operators and control decisions can be passed to the grid with the help of GUIs. The “Big data problem” put forth by large data in smart grid can be addressed using cloud based architecture. The research can be extended considering the security aspects in smart grid communication system. Rapid penetrations of communication into power grid, and growing concerns about cyber security have attracted significant attention towards smart grid cyber security. Cyber security in the smart grid must be carefully designed to meet power system operation’s functional and reliability requirements [12].

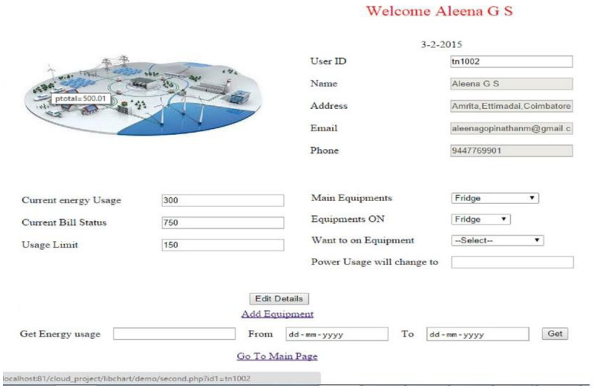

Fig. 6. GUI for Consumer

References

[1] Mayilvaganan, M. Sabitha, ,A cloud-based architecture for Big-Data analytics in smart grid: A proposal, IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), vol.1, no.4, p.26-28 Dec. 2013.

[2] Hongseok Kim, Young-Jin Kim; Kai Yang, Thottan, M., loud-based demand response for smart grid: Architecture and distributed algorithms, IEEE International Conference on Smart Grid Communications (SmartGridComm), vol.398, no.403, p.17-20 Oct.2011

[3] POPEANGĂ, Janina. Cloud Computing and Smart Grids., ERP and E- Business Application Deployment in Open Source Distributed Cloud Systems: vol.3, p.57-66, 2012.

[4] What is the Smart Grid? https://www.smartgrid.gov/the_smart_grid/smart_grid.html, Accessed on: [12-07-2014].

[5] Fang, Xi, et al. "Smart grid—The new and improved power grid: A survey , Communications Surveys & Tutorials, IEEE vol.14, no.4, p.944-980, 2012.

[6] Nithin S, Sasi K Kottayil and T N P Nambiar. , Development of a Smart Grid Simulator, Proceedings of National Conference on Power Distribution, CPRI, India, 2012.

[7] Rusitschka, Sebnem, Kolja Eger, and Christoph Gerdes. , Smart grid data cloud: A model for utilizing cloud computing in the smart grid domain., First IEEE International Conference on Smart Grid Communications (SmartGridComm), vol.4, No.6, p. 483-488, 2010.

[8] Simmhan, Yogesh, et al. ,Cloud-based software platform for data-driven smart grid management., IEEE/AIP Computing in Science and Engineering, pp. 1-6, 2013.

[9] Fang, Xi, Satyajayant Misra, Guoliang Xue, and Dejun Yang. ,Managing smart grid information in the cloud: opportunities, model, and applications., Network, IEEE ,vol.26, no. 4, p.32-38, July-August 2012.

[10] Balijepalli, VSK Murthy, and S. A. Khaparde. , Smart Grid Standards Conformed Cloud Based Demand Side Management Tools., International Journal of Engineering Research and Technology. Vol. 1. No. 5, p. 1-7, July 2012.

[11] Cloud Report – Dzone- http://dzone.com/research/cloud, Accessed on: [10-12-2014].

[12] Weerathunga, Pubudu. SECURITY ASPECTS OF SMART GRID COMMUNICATION (Spine title: Security Aspects of Smart Grid Communication)(Thesis format: Monograph). Diss. Western University London, 2012.

[13] Samaresh Bera, Sudip Misra and Joel J.P.C. Rodrigues. ,Cloud Computing Applications forSmart Grid: A Survey, IEEE Transactions On Parallel And Distributed Systems, vol. 26, No. 5, p. 1477- 1494, May 2015.

[14] Simmhan, Yogesh, et al. , On using cloud platforms in a software architecture for smart energy grids., IEEE International Conference on Cloud Computing (CloudCom). 2010.

[15] Melike Yigit, V. Cagri Gungor and Selcuk Baktir. ,Cloud Computing for Smart Grid applications" Computer Networks vol.70, p. 312-329, 2014.